ANALYSIS OF THE COLOR-MAGNITUDE DIAGRAMS OF THE DWARF GALAXIES UGCA 105 AND UGCA 86

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Abstract.

The method of the brightest star color distributions on the color-magnitude diagram is applied order to determine the foreground extinction toward two Im galaxies, seen through the Milky Way disk. The accuracy of the derived extinction values is estimated to be about 0.2 mag. The CCD photometry in V and I bands published by Karachentsev et al. (1997) is used. The extinction estimates toward UGCA 105 and UGCA 86 are 0.94 mag and 5.33 mag, respectively. They are significantly different from the catalogue values, 1.35 mag and 4.06.mag (Schlegel et al. 1998), but the most appropriate respective isochrones explain better the apparent color-magnitude diagrams. It seems that the brightest disk region of UGCA 86, known as VII Zw 9, is located along a sightline of lowered extinction (3.29 mag).

Key wors: galaxies – dwarfs, galaxies – stellar populations; galaxies UGCA 105, UGCA 86

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The IC 342/Maffei complex galaxies are situated very close to the plane of the Milky Way (MW) and their study is strictly limited by the foreground extinction and foreground star contamination (see Karachenstev et al. 1997, Buta & McCall1999). In such cases the foreground extinction may be estimated on the basis of the mean color of the blue plume of the color-magnitude diagram (CMD) of the studied galaxy. For this purpose we build the differential distribution of the brightest resolved galaxy stars according to the color index, called here the color function (CF). This approach is applied on published photometry of Karachentsev et al. (1997), based on observations with the Nordic Optical Telescope.

The average color index of the OB stars on the CMD (as well as the position of the respective local maximum of the CF) depends weakly on the metal abundance. Our preliminary studies show that the mean color indexes of the blue plume is $(B\text{-}V)_0 \approx (V\text{-}I)_0 \approx$

–0.1. In the case of low metallicity the mean color index of the red plume is $(B\text{-}V)_0 \approx 1.5$ or $(V\text{-}I)_0 \approx 1.7$ (see Georgiev 2002 and references therein). The error estimation of the CF local maximum determination and of the color excess (here $E(V\text{-}I)$) is about 0.05 mag. Therefore the standard error of the extinction in B band is $A_g = E\ (V\text{-}I)/0.32 \approx 0.2$ mag. The mean color of the top of the red plume on the CMD could be used as check for derived value A_g, as well as for the selection of the isochrones set with an appropriate metallicity. Unfortunately, the plume of the red stars is highly inclined and its mean color index is in principle poor defined.

In the case of observation through MW disk an additional important information about the foreground extinction may be obtained from the mean color index of the foreground stars, as follows. The number of the stars in front of the majority of the absorption medium must be significantly less than the number of the stars behind it. Therefore big part of the strongly reddened stars, mainly KM dwarfs, must be MW stars placed behind the absorption medium. According to the model of the MW's stellar population of Robin et al. (2003) the main true color index of the CF peak of the MW stars is $(V\text{-}I)_f \approx 0.8$.

The method applied here consists of 5 steps, as follows: (1) We construct the CMD in coordinates (V-I) – V and had determined the upper limiting magnitude V_0 of the brightest blue stars suspected as members of the studied galaxy. (2) Next we build CFs with upper limit V_0 and magnitude interval (this work) $\Delta V = 3$ mag, with step and interval along the color index axis of $(V\text{-}I) = 0.05$ and 0.1 mag (this work), respectively. Further we smoothed the CFs accounting for three neighboring points with weights of 0.25, 05 and 0.25. If the photometry is deeper, we may build a set of CFs with $\Delta V = 3$ mag, increasing V_0. Also in cases of severe foreground star contamination we build the CF of the stars brighter than V_0. (3) We derive the apparent mean color indexes $(V\text{-}I)_b$, $(V\text{-}I)_r$ and $(V\text{-}I)_f$,, corresponding to the blue, red and foreground plumes of the CMD. (4) A corrections for the foreground extinction and the distance modulus (DM) of the galaxy was applied. (5) Having estimation of A_B and DM we superimpose set of isochrones with a fixed metallicity over CMD in order to obtain the best fit of the galaxy stellar population. The preliminary analysis of the CMDs of the studied galaxies showed that the red plumes are slightly shifted, corresponding to $(V\text{-}I)_0 = 1.75$ and thus, the isochrones with Z=0.008 we considered to be are the most appropriate.

Table 1 summarizes the gross-properties of the studied galaxies, available from the LEDA data base – the size of the galaxy *a* in arcminutes,

the axial ratio *b/a*, the total magnitude B_t, the foreground extinction in B-band A_g, HI line width W_{50}, as well as the expected mean color indexes the blue and red plumes, $(V\text{-}I)_b$ and $(V\text{-}I)_r$, according to the A_g, adopted in LEDA. The last three columns contain the distance modulus DM, the total absolute magnitude M_B and the galactic latitude b_{MW} (in degrees). In the case of UGCA 105 the DM is derived by Karachentsev et al. (2002) according to the location of the Tip of the Red Giant Branch (TRGB). In the case of UGCA 86 Karachentsev et al (2003) does not found the TRGB and we adopt the distance estimation of Karachentsev et al. (1997) based on the brightest galaxy stars, corrected with the value for A_g adopted in LEDA.

Table 1. Basic data of the studied galaxies.

Galaxy	a	b/a	B_t	A_g	W_{50}	$(V\text{-}I)_b$	$(V\text{-}I)_r$	DM	
	M_B	b_{MW}							
UGCA 105	5.5	0.64	12.14	1.35	118	0.33	2.18	27.49	-
16.70	13.7								
UGCA 86	4.5	0.69	13.50	4.06	83	1.20	3.05	27.38	-
17.94	10.6								

The data in Table 1 shows that the two studied Im galaxies are very similar to each other, however, the less massive and strongly obscured galaxy UGCA 86 has surprisingly high luminosity. One possible explanation is an overestimated distance modulus. Further we will consider separately the south-eastern part of the frame of UGCA 86, published by Karachentsev et al. (1997), constrined by the pixel values X>600 and Y>600, and called here UGCA 86b. It covers the brightest part of the disk of UGCA 86, known also as object VII Zw 9. The gas velocity field published by Robin et al (2003), shows that VII Zw 9 is a part of the disk of UGCA 86s. The UGCA 86b area covers 37% of the frame and contains 254 stars (57% of all measured). The rest part of the frame here is called UGCA 86a.

Table 2 contains the quantities derived in this work – the mean color indexes of the blue, red and foreground stars plumes on the CMDs, $(V\text{-}I)_b$, $(V\text{-}I)_r$ and $(V\text{-}I)_f$, respectively, the foreground extinction $A_g = (V\text{-}I)_b/0.32$ and the distance modulus *DM*, corresponding to Table 1, but corrected with A_B, obtained in this work. The data given in Table 2 concerns UGCA 86b only, because our UGCA 86a data is identical to UGCA 86 data.

Table 2. The quantities, derived in this work.

Galaxy	$(V\text{-}I)_b$	$(V\text{-}I)_r$	$(V\text{-}I)_f$	A_g	DM	M_B
UGCA 105	0.20	2.05	0.97	0.94	27.67	-16.47
UGCA 86	1.60	3.45	2.35	5.33	26.11	-17.94
UGCA 86b	0.95	2.80	-	3.29	28.15	-

The CMDs and CFs of the galaxies UGCA 105 and entire UGCA 86 are shown in Figure 1. Some of the stars (the total numbers are 568 and 444, correspondingly) fall outside the selected CMD limits. The upper brightness V_0 is determined to be 20.4 mag for UGCA 21.8 mag – фор UGCA 86. In the case of UGCA 105 we show also two "deep" CF, with upper limitc 21.9 mag and 22.4 mag, respectively. Each rectangle in Figure 1, delineated with a solid line, has a width of 1 mag and encompasses the brightest parts of the blue and red plumes in the galaxy, populated by supergiant candidates. They are centered on the derived here values for $(V\text{-}I)_b$ and $(V\text{-}I)_r$, given in Table 2. The isochrones of Padova group (Z=0.008 and ages between 13.6 and 31.6 Myr), corrected with the values of A_g and DM, adopted in Table 1 (dashed curves) and Table 2 (solid curves) are superimposed. The "main" CFs are represented by solid curves. The foreground stars and UGCA 105 CFs, are plotted with short dashed curves. Dashed vertical lines demarcate the expected mean color indexes of the blue and red plumes, corresponding to the extinction given in Table 1, but solid vertical lines - the apparent mean color indexes $(V\text{-}I)_b$, $(V\text{-}I)_r$ and $(V\text{-}I)_f$, given in Table 2.

In the case of UGCA 105 we found two well defined plumes of the blue and red stars and the derived extinction (0.94 mag) is less than that given in catalogue data (1.35 mag) (Schlegel et al. 1998). The position of blue plume on the CMDs, obtained with the Hubble Space Telescope (Karachentsev et al. 2002, 2003) confirms the derived estimations. The position of the foreground star plumes gives even slightly smaller value of the foreground extinction. In Fig.1 the isochrones, corrected with our extinction value (solid curves) explain slightly better the populated parts of the CMD, too. Generally, we may conclude that in the last 10-15 Myr UGCA underwent a new starforming event, while during the past such period has finished roughly 30 Myr ago.

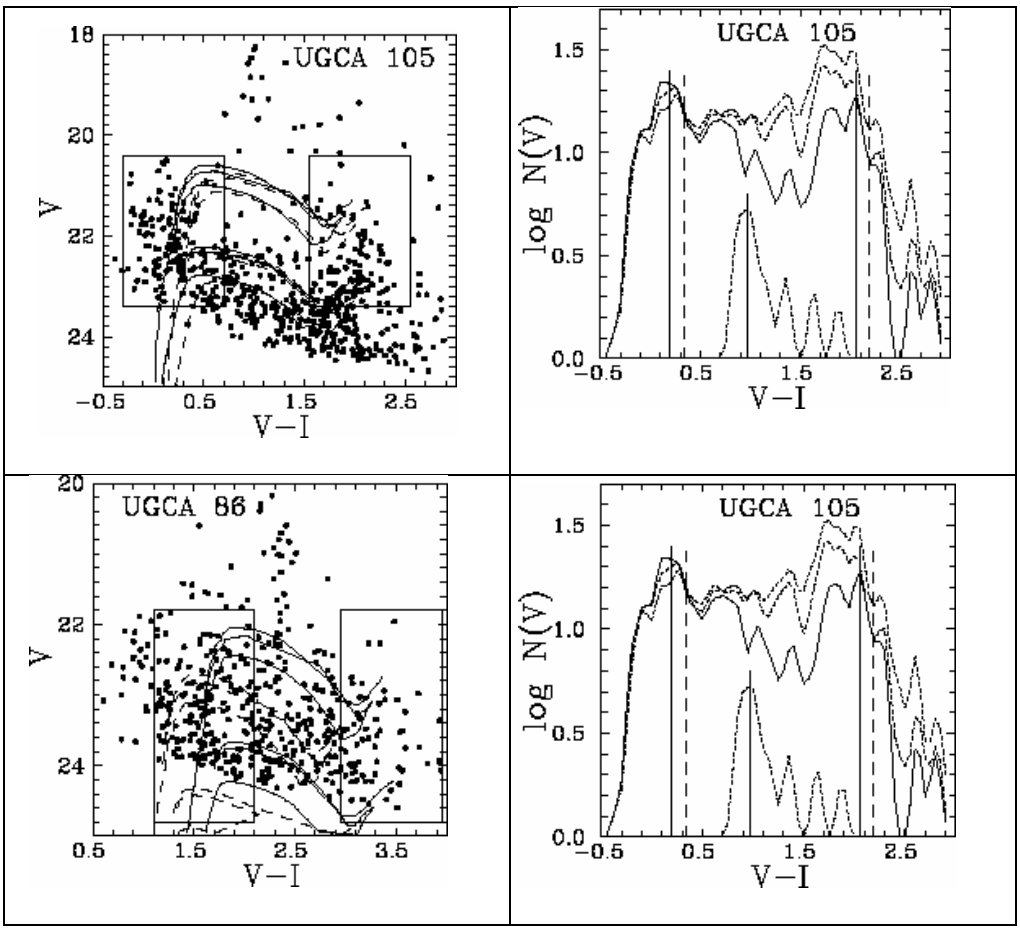

Fig. 1. Color-magnitude diagrams and color functions for the brightest stars in UGCA 105 and UGCA 86 (see the text).

The UGCA 86 CF shows many local maximums. The positions of the two of them are in a good agreement with catalogue extinction value in LEDA of 4.06 mag (Schlegel et al. 1998). However, the positions of the highest maximum and the position of the foreground stars plume, correspond to a higher extinction – 5.33 mag. The expoected well-pronounced maximum of the red stars is missing, but this could be explained with the limited depth of the observation in V-band. Moreover, the most populated parts of the CMDs are better fiited by the color indexes of the isochrones with a higher extinction correction (solid curves) applied. However, if we adopt such a high extinction, the distance modulus, based on

the brightest stars selected by of Karachentsev et al. (1997), becomes too small – 25.75 mag.

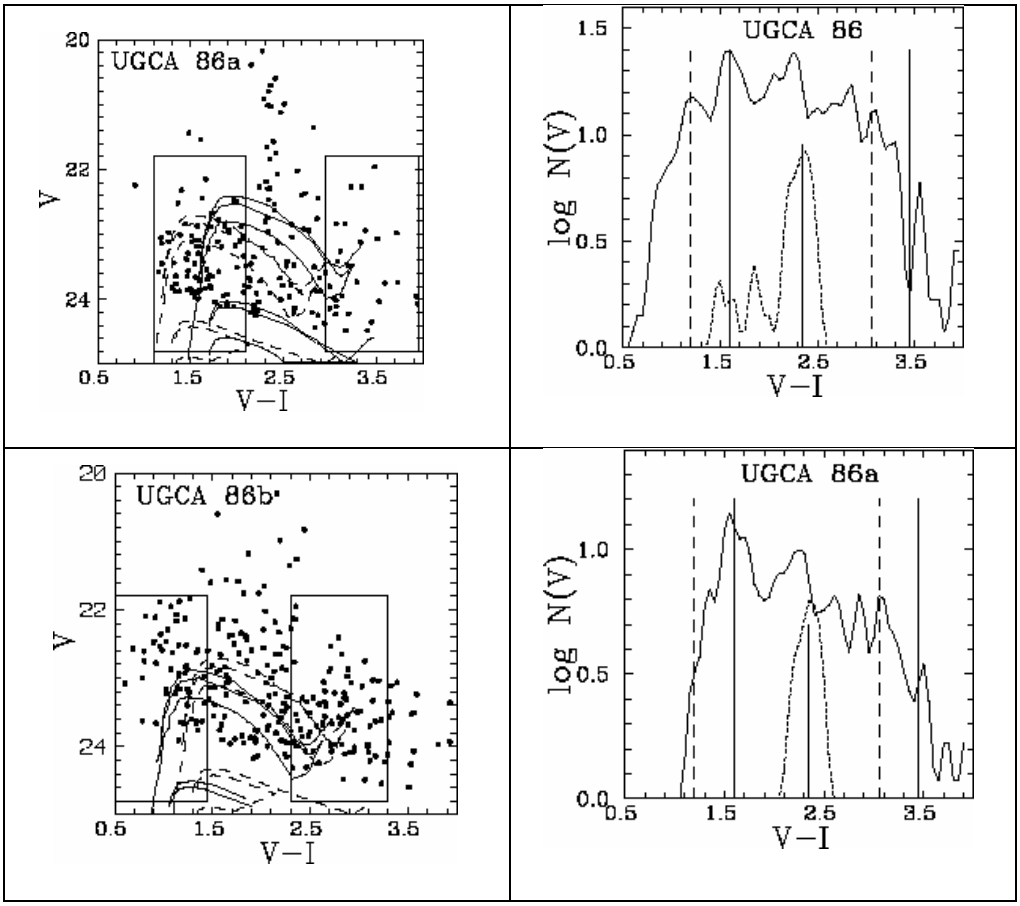

Fig. 2. Color-magnitude diagrams and color functions for the brightest stars in two parts of the galaxy UGCA 86 (see the text).

In Fig.2 we compare two CMDs of UGCA 86 – for UGCA 86a and UGCA 86b. The derived quantities for UGCA 86a are identical with those for the whole galaxy. However, the derived data about UGCA 86b are significantly different. The extinction value is significantly lower (3.29 mag), the foreground stars plume is missing and the respective corrected distance modulus occurs to be too high – 28.15 mag. The superimposed isochrones does not explain the observed CMD of UGCA 86b. Therefore, we could suspect that the brightest part of UGCA 86 is a stellar complex seen through relatively transparent “window” of MW having significantly

lowered extinction along that sightline. Generally, UGCA 86 continues to seem similar to UGCA 105, but the lack of coherent distance determinations strongly limits the possibilities for a more detailed study.

Here we reported a brief analysis of CMDs of two strongly obscured galaxies using the CFs method. Our aim was to derive an extinction estimate based mainly on photometry criteria. In the case of UGCA 105 we obtained rough estimates about the star forming history. We conclude also that the MW extinction in direction toward UGCA 86 galaxy is similar to UGCA 105 and is strongly inhomogeneous. Thus, a deeper photometry is necessary to figure out the problem with the distance modulus.

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